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An Investigation of Stimulus Complexity And Öhman's Priming Theory in the Elicitation of the Electrodermal Orienting Response

By

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AN INVESTIGATION OF STIMULUS COMPLEXITY AND ÖHMAN'S PRIMING THEORY IN THE ELICITATION OF THE ELECTRODERMAL ORIENTING RESPONSE

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Abstract

Previous research has yielded equivocal results as to the role which stimulus complexity plays in the elicitation of the orienting response. Previous research has shown that responses to complex stimuli are more probable and of greater magnitude than responses to a simple stimuli. Other research has failed to find this effect. This discrepancy arises from an attempt to determine those important aspects of a stimulus which lead to OR elicitation. The purpose of the following study was to further investigate the role of stimulus complexity in the elicitation of the orienting response. Subjects were 22 Introductory Psychology students (11 males and 11 females) who participated for course credit. Skin conductance was measured. Participants were randomly assigned to two conditions. Six stimuli were presented in each condition. For condition one, trials 1 to 4 and 6 consisted of a tic-tac-toe grid; trial 5 was a horizontal bar. Condition two was presented with the same sequence of events with the stimuli reversed. No significant differences were found for mean response magnitude to trials 1, 5, and 6 between conditions. Similarly, the probability of response to these same stimuli did

not significantly differ between conditions. Results are discussed in terms of Öhman's (1979) priming theory.

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Introduction

Cognitive Psychophysiology is a discipline that studies the physiology associated with the thought processes of an organism. The purpose of this endeavor is to better understand the processes of mind and brain and the relations between them. This relation between physiological processes and thought is the topic of this paper.

There are two main purposes to the following discussion. The first is to introduce the concept of phenomena in the autonomic nervous system as indicators of information processing. The second purpose is to examine, in depth, the orienting response and its role in informational processes.

What is the orienting response?

Historical Perspectives

Pavlovian influence

With the publication of Pavlov's book, Conditioned Reflexes, an Investigation of the Physical Activity of the Cerebral Cortex, the scientific study of physiology, innate reflexes, and learning occurring in Russia was brought to the attention of the Western scientific community. Pavlov, a physiologist, outlined in his book his research and a new approach to the study of learning. It was not Pavlov's intent to investigate the psychology of learning, for as already stated he was a physiologist. Rather, he hoped to investigate, and offer an account of, the importance that physiological reflexes have for an organism. Pavlov believed that all behavior was made up of reflexes and that these

reflexes represented underlying sub-cortical activity.

> It may be hoped that some of the more complex activities of the body, which are made up by a grouping together of the elementary locomotor activities, and which enter into the states referred to in psychology as "playfulness," "fear," "anger," and so forth, will soon be demonstrated as reflex activity of the sub-cortical parts of the brain. (Pavlov, 1927, p. 4)

Pavlov discussed several reflexes in his book that were vital in understanding the behavior of an organism. Some of these are the feeding, freedom, investigatory, and conditioned reflexes. Of these the conditioned reflex has been most studied. Less emphasized, yet potentially as important, is Pavlov's investigatory or "what is it" reflex.

> It is this reflex which brings about the immediate response in man and animals to the slightest changes in the world around them, so that they immediately orientate their appropriate receptor organs in accordance with the perceptible quality in the agent bringing about the change, making full investigation of it...If the animal were not provided with such a reflex its life would hang at every moment by a thread. (Pavlov, 1927, p. 12)

Pavlov noticed that even the slightest alteration in environmental stimuli would evoke this response in his experimental dogs. Every time he or one of his experimenters carried bells, lights, metronomes, etc. (anything that would later be used as conditioned stimuli) into the lab, the dogs would orient to the stimuli. He also discovered that only those stimuli that elicited this reaction could serve as effective conditioned stimuli in later learning tasks (Kimmel, 1979, p. xxi; Pavlov, 1927, p. 29). He noticed overt behaviors in his dogs, such as their ears perking up and their heads turning. It

was these behaviors that led him to theorize about their function (Pavlov, 1927, p. 13). For Pavlov, the orienting reflex was a way in which the animal marshalled sensory resources so that the stimuli that elicited the orienting response could be more effectively processed (Pavlov, 1927, p. 12).

One final item of importance in Pavlov's earlier development of the significance of the orienting reflex is its relation to classical conditioning. Pavlov found that stimuli that elicited an orienting reflex, if they were repeatedly presented, would come to have less and less of an effect on the organism until an orienting reflex no longer occurred (a phenomenon now termed habituation). However, if the stimuli were sufficiently strong or unusual, they would continue to elicit an orienting reflex and conditioning would become much more difficult, if not impossible (Pavlov, 1927, p. 29). In other words, he saw the orienting reflex as an obstacle that would have to be removed before classical conditioning could occur (Öhman, 1983, p. 315-316).

Sokolovian influence.

Eugene Sokolov continued the Russian physiological tradition. Sokolov published two very influential works in the early 1960's. The first was a chapter entitled 'Neuronal Models and the Orienting Reflex,' in The Central Nervous System and Behavior. Here, Sokolov continued work on the orienting reflex (the foundation of which had been laid by, among others, Pavlov, Konorski, Anohkin, and Krakov (Siddle, 1983, p. 5,7)) and established the early formulations relating the orienting

response to its functional significance. According to Kimmel (1979, p. 4), Sokolov showed that the orienting response habituated, not because of neuron fatigue, but rather because some higher order processing was occurring. He discovered that, simply by changing a dimension (e.g. pitch, intensity) of the habituated stimulus, a re-elicitation of the orienting reflex occurred. Assuming that many of the same neurons would be analyzing this altered stimulus (given that it was presented in the same sensory modality), this response would not have been possible if the neurons had fatigued.

Based on his habituation findings, Sokolov developed a neuronal model in which a representation of the environment is formed in the nervous system. Any change in stimuli would be matched against this model, and an orienting response would be elicited if the new stimulus did not match the current pattern (Pribram, 1979, p. 4). He hypothesized that sensory input enters the cortex, where a model of the stimulus begins to form. The stimulus also activates the reticular formation. When a new stimulus is introduced, it does not match the current neuronal model, and the excitatory impulse reaches the reticular formation via cortico-reticular connections. Activation of the reticular formation in this manner elicits an orienting response. At the same time, the reticular formation has an activating effect on the discriminatory power of the comparator. Repeated presentation of the stimulus leads to development of a neuronal model. The similarity of the stimulus to the neuronal model has

an inhibitory effect on reticular formation activity and hence inhibits the orienting response (Stephenson & Siddle, 1983, p. 190). This model is adequate to explain the elicitation of the orienting response to novel stimulus. Similarly, it can account for habituation. However, the weakness of this model is that it does not explain orienting response elicitation to repeated significant stimuli. Öhman (1979) made use of the basic components of Sokolov's model formation process when he proposed his model for the functional significance of the orienting response. This model will be elaborated on later.

Sokolov's second work that had a major impact on understanding the psychophysiology and functional significance of the orienting response was Perception and the Conditioned Reflex. In this book Sokolov built upon the work of Anohkin and proposed that there were several unconditioned and conditioned responses whose functions were to regulate sensory analyzers. The three unconditioned responses he posited were the orienting response, the defensive response, and the adaptive response. Each of these reflexes was composed of different physiological components and served different purposes (Sokolov, 1963, p. 10-15).

Sokolov further subdivided the orienting response into the localized and generalized orienting response, and the tonic and phasic orienting response. The localized orienting response only arises in the analyzer stimulated. Sokolov used the example of tactile stimuli that elicit the skin conductance response component of the orienting response. A generalized orienting

response consists of an increase in sensitivity within a number of different analyzers. In this case the stimulus elicits an orienting response composed of many physiological components (i.e. a visual stimulus eliciting a skin conductance, heart rate, and brain wave response) (Sokolov, 1963, p. 79-80). Sokolov's second division is that between phasic and tonic orienting responses. The transient increase in analyzer sensitivity elicited by a stimulus can be considered a phasic orienting response. The tonic orienting response is characterized by a background increase in analyzer sensitivity which may outlast the duration of stimulus presentation (Sokolov, 1963, p. 116; Turpin, 1983, p.10).

One last point to draw from this work concerns the defining characteristics of the adaptive, defensive, and orienting reflexes. The adaptive and defensive reflexes will be elaborated on shortly. First, we consider the defining features of the orienting response as proposed by Sokolov: (1) non-specificity as regards the quality of the stimulus, (2) non-specificity as regards the intensity of the stimulus, and (3) selectivity of extinction of various properties of the stimulus with repeated presentations (Turpin, 1983, p. 9).

Although there are a host of other scientists who have contributed to present-day knowledge of the orienting response, Pavlov and Sokolov have contributed the most. They have had their impact, not so much in the current understanding of the orienting response, but rather in laying the theoretical

foundations upon which much of the current theory rests.

Other autonomic responses

Although the primary purpose of this paper is to examine the orienting response, the discussion would not be complete without a brief look at the components and functions of some other important autonomic responses.

Adaptive reflex.

The least examined autonomic response is the adaptive reflex. "Originally the term adaptation referred to changes in receptor sensitivity which occurred against a background of continuous stimulation" (Turpin, 1983, p. 8).
Makarov, in 1955, applied the term "adaptation" to the set of reflexes which controlled the functional characteristics of the analyzer according to internal and external conditions (Sokolov, 1963, p. 14). "The action of the reflex is contingent upon the continued presence of the stimulus, and with repeated presentations of the stimulus the reflex becomes more stable and may even be pronounced " (Turpin, 1983, p. 8). The purpose of this set of specialized reflexes is to bring about the adaptation of the sensory analyzers to the quality and intensity of the stimulus (Sokolov, 1963, p. 14). An example of an adaptation reflex is the collection of thermoregulatory reflexes that an organism manifests to control its body temperature in relation to changing environmental conditions. These include such reactions as increased perspiration and peripheral vasodilation in response to heat and inhibition of perspiration and peripheral

vasoconstriction in response to cold (Sokolov, 1963, p. 36). The difference between the adaptive response and orienting response is that the adaptive response's purpose is to adapt sensory analyzers to stimuli, whereas the orienting response's purpose is to enhance the organism's ability to process stimuli (Sokolov, 1963, p, 14).

Startle reflex.

Another autonomic response, one that has been more thoroughly studied, is the startle reflex. The startle reflex can be differentiated from other reflexes by its particular autonomic components. These include: (1) heart rate acceleration, (2) rapid habituation (Graham, 1979, p. 149; 1984, p.173), (3) unique skeletal muscle pattern (Graham, 1979, p. 145), (4) cephalic vasodilation, and (5) digital vasoconstriction (Turpin, 1986, p. 3). Graham (1979, p. 151) sees the function of the startle response as that of an interrupt system. When there is a significant rate of change in stimulus energy (i.e., quality, intensity, rise time (Turpin, 1983, p. 42)), a startle is elicited, and the organism interrupts current activity in anticipation of future processing (Graham, 1979, p. 151).

The magnitude, response probability, and rate of habituation of the startle response are all a function of stimulus intensity and rise time (Graham, 1979, 145-150; Turpin, 1983, p. 42). The increased heart rate component of the startle response is its most important feature. Sokolov proposed that heart rate acceleration was part of the orienting response (Graham &

Clifton, 1966, p. 306). Since Sokolov viewed the orienting response as a way of increasing sensory sensitivity, it follows that increased heart rate would serve some physiological function to facilitate stimulus enhancement. This is an exact contradiction to the hypothesis proposed by the Laceys. Graham and Clifton (1966) review the Lacay's argument (Lacey & Lacey, 1958) in which the Lacey's cite several lines of research showing that increased heart rate activity actually leads to a decrease in cortical activity. Thus, they postulated that heart rate acceleration facilitates a decrease in sensitivity and hence a rejection of environmental stimuli. It is now widely believed that heart rate acceleration is not a component of the orienting response as Sokolov proposed but rather a component of the defense and startle responses. Thus, increased heart rate does not facilitate information intake. Rather, it serves to decrease cortical activity, which may decrease analyzer sensitivity. This makes sense, because stimuli that are excessively intense or surprising could cause more harm to organisms if there sensory systems did not act to protect them from such stimuli.

Defense reflex.

A third autonomic response is the defense reflex. Sokolov (1963, p. 14) describes the defense reflex as serving the same purpose as the adaptation response: it limits the action of an intense stimulus. Whereas the adaptive reflex is specific to certain sensory analyzers (i.e. pupil constriction in response to a bright stimulus), the defense reflex is a reaction of the

entire body to a stimulus (Sokolov, 1963, p. 14). The defense response serves to protect the organism from the eliciting stimulus; it does not enhance the organism's ability to process the stimulus.

In many ways the defense response and startle response are similar. There are two main differences between them. The first is the rate of habituation. The startle response habituates very rapidly (Graham, 1979, p. 149). The defense reflex, however, habituates slowly, if at all (Graham, 1979, p. 141-142). Turpin and Siddle (1983) question this habituation distinction. In their study, even though skin conductance, heart rate, and digital pulse amplitude all matched the defensive response profile, rapid habituation was observed (Turpin, 1986, p. 5), a finding that is inconsistent with Sokolov's or Graham's defense profile. Turpin notes there are (1) methodological differences between early studies and Turpin's own, (2) individual differences between subject groups, and (3) competition among the orienting, startle, and defense responses. A second difference between the defense response and the startle response is that there is cephalic vasodilation in the latter and cephalic vasoconstriction in the former. In summary, autonomic nervous system researchers are currently concerned with three main reflexes, the orienting response, the defense response, and the startle response. One of these, the orienting response, is the main focus of this paper.

What is the functional significance of the

orienting response?

Distinguishing features of the orienting response

Pavlov saw the overt musculature response of the organism as an indication of the orienting response. Sokolov (1963, p. 12-13) cited further indices of the orienting reflex, including secretion of saliva, pupil dilation, changes in respiratory rhythm, changes in brain electrical activity, and a galvanic skin response. Specifically, a low to moderate stimulus eliciting an orienting response will be followed by several autonomic components, including: decrease in heart rate, an increase in skin conductance, digital and cephalic vasoconstriction (Turpin, 1986, p. 3), and brain wave changes (Loveless, 1983, p. 27).

Rubrics of orienting response research

The orienting response effects the information processing capacity of an organism. At what level this effect occurs is still a subject of speculation. Three levels occupy the current mainstream of orienting response research: the orienting response as a facilitator of attention, as a facilitator of stimulus information, and as a more general, overall facilitator of information processing.

As a facilitator of attention.

Sokolov (1963) proposed that one of the functions of the orienting response was to increase analyzer sensitivity. By increasing analyzer sensitivity, the orienting response allows the organism to be attentive to other stimuli that may occur. Deutsch and Deutsch (1963, p. 83-85) elaborated on this when they

discussed the idea of threshold levels. They argued that an organism maintains a certain threshold in the brain, and a stimulus that exceeds this threshold level elicits an orienting response. The elicitation of the orienting response increases analyzer sensitivity and thus lowers the threshold level, so stimuli that would have at first gone unnoticed become eligible for future processing (Deutsch & Deutsch, 1963, p. 85). Furthermore, general arousal and length of time of increased arousal are proportional to the importance of the stimulus. The organism itself determines this initial threshold, in that a state of high attention would mean a very low threshold, whereas a state of non-attention (such as sleep) would require a stimulus of considerable intensity to cross the threshold and elicit an orienting response.

These early conceptions of the attentional function of the orienting response have been bolstered by recent research. Frith and Allen (1983, p. 35) report that subjects exhibit greater skin conductance responses to novel tones occurring during task performance than to tones occurring outside of task performance. Because the subject is engaged in a test that requires attention, his/her sensory threshold is lower, and thus novel tones elicit orienting responses. The orienting response thus reflects an enhanced state of attention rather than a direction of attention. According to Frith and Allen (1983), Kroese and Siddle (1981) demonstrated similar findings. They showed that increasing a secondary task demand retarded habituation. They hypothesized

that, with a decreased level of arousal, the tones begin competing with task demands for available processing resources, and thus less processing resources were given to both tasks and habituation took longer. Finally, Goldwater (1979) reported increased orienting responses while a subject watched a movie of high interest, while a subject who watched a movie of little interest responded less to innocuous stimuli.

Kahneman (1973) has also proposed a theory of the orienting response's relation to attention. Based on the low correlations among various manifestations of the orienting response, he hypothesized that it is better to view the orienting response as a set of independently controlled changes which occur together because together they are adaptive on the same occasions (Kahneman, 1973, p. 46-47).

Kahneman distinguished among four components of the orienting response: (1) "A transient effort to process and analyze the alerting stimulus." (2) "Inhibition of ongoing activity." (3) "An orientation toward probable sources of future significant information," and (4) "A transient increase of arousal." (Kahneman, 1973, p. 47-48). He further stated that responses made to stimuli to which the subject is told to pay voluntary attention should not be classified as orienting responses. He felt that the orienting response should be viewed as a loose set of physiological changes, each independently controlled by some aspect of the stimulus information and response to that situation (Kahneman, 1973, p. 49).

Kahneman's conception of the orienting response is important for two reasons. First is his notion that the orienting response results from preliminary, preattentive processes. This attentional mechanism pre-analyzes the stimulus, and an orienting response is elicited if some degree of novelty, significance, or an insufficiently detailed interpretation of the stimulus is detected (Spinks & Siddle, 1983, p. 242-244). The second point of importance is that by separating the orienting response from information processing, equivocal results that are obtained in orienting response research can be better understood. In Kahneman's view it is important to control methodologically whether it is orienting being studied (in the case of a truly involuntary perception of the stimulus) or some other information process (in the case of voluntary attention). Kahneman's notion of the orienting response may be a bit cautious in denying the role of the orienting response in voluntary attention. Nonetheless, it is an important theory, in which he has attempted to schematize more fully the role of the orienting response in attention and has given a possible explanation for the low correlations found between orienting response results.

Taken together, the above studies support the notion that one possible function of the orienting response is to increase analyzer sensitivity and have a facilitative function on an organism's attentional mechanism.

<u>As a facilitator of stimulus information</u>.

The second possible role of the orienting response lies in

its relation to stimulus information. Stimuli can convey three types of information: (1) intrinsic information - information contained within a stimulus due to its complexity, (2) extrinsic information - the probability of stimulus occurrence, and (3) information contained about future stimuli or responses (Siddle, Stephenson, & Spinks, 1983, p. 126).

Berlyne, Craw, Salapatek, and Lewis (1963, p. 567) found that, when subjects were presented with highly complex, incongruous, or irregular stimuli, they showed more skin conductance response elicitation than if the stimuli were less complex, irregular, or incongruous. However, these effects were only obtained when the subjects were told they would later be quizzed on these stimuli. Siddle et al. (1983, p. 127) report that Fredrickson and Öhman (1979) found comparable results. Complexity led to slower habituation as measured by trials-to-habituation, and complex stimuli elicited cardiac responses. Finally, Spinks and Siddle (1976, p. 36) reported that subjects presented with low-information stimuli (less complex stimuli) required fewer presentations to achieve skin conductance response habituation and showed fewer skin conductance responses than did those presented with higher-information stimuli (higher complexity). These results were only obtained when subjects were told that they would be tested later.

The second type of information a stimulus can convey is extrinsic information. This refers to the information that a stimulus conveys about the probability of another stimulus'

occurrence. Heart rate and skin conductance vary in proportion to the probability that the stimulus will occur (Siddle et al., 1983, p. 130). A typical study purporting to show this effect is one by Lovibond (1969). By manipulating the probability with which one stimulus predicts another, Lovibond found that the mean skin conductance magnitude to stimulus one varied as a function of the predictive probability of stimulus two. Lovibond also found that the greatest skin conductance response occurred at 0.5 probability level.

The third type of information that can be contained within a stimulus is information about future stimuli or responses, in other words, the signal value of a stimulus. The results on signal value of a stimulus are equivocal. Subjects who are told they will later be tested on the presented stimuli show little difference in orienting response patterns compared to subjects told to ignore the stimulus (Siddle et al., 1983b, p. 136). That is, signal value appeared to have no effect. However, Siddle et al. (1983b, p. 137) and Glimer et al. (1971) found that if subjects were told they will later be required to make judgments about a stimulus, then larger responses can be seen compared to control groups. Siddle et al. (1983) concluded that studies investigating the signal value of a stimulus have produced mixed results.

<u>As a facilitator of information processing</u>.

The third area that has received a great deal of attention in orienting response research is the orienting reflex's relation

to the general information processing capabilities of an organism. This includes how an organism attends to stimuli as well as the further processing that stimuli may undergo.

Models that try to explain the orienting response in terms of information processing take an approach similar to that of Atkinson and Shiffrin. Atkinson and Shiffrin proposed a model of information processing involving three components (Gardner, 1985, p. 122). The first is a sensory store, where a stimulus is registered within the appropriate sensory system. The storage capacity of this store is extremely large, storing virtually all the information reaching an organism's senses. The second component is short-term memory. Short-term memory determines what information is significant and begins to process that information. The capacity of short-term memory is relatively small; it is only able to process approximately seven plus/minus two chunks of information. Information will decay in about fifteen to thirty seconds unless it is passed into a rehearsal buffer. The longer the information remains in the rehearsal buffer, the greater the probability of it passing into long-term memory. Information that crosses into long-term memory is believed to be relatively permanent.

Sokolov, based on the research on selective attention by he and Veronin (1958) proposed a neuronal model. He argued there is a certain cell system wherein information about the stimulus is stored after repeated presentation. The orienting response occurs as the result of a mismatch between the presented stimulus

and the neuronal model. An orienting response decrement is noticed because the model eventually becomes a near perfect representation of the stimulus. At this point, matching occurs and the orienting response habituates. Whatever parameter of the stimulus is changed, an orienting response will be re-elicited because the stimulus administered fails to coincide with the current neuronal model. The greater the difference between the model and the delivered stimulus, the greater the reaction (Sokolov, 1963, p. 286-288). Grim and White (1965) report evidence that is in line with this hypothesis. They presented their subjects with red light stimulus for 16 habituation trials. On the 17th presentation, one of four colors was presented. On each presentation of the stimuli, the subject was required to move a lever. Reaction time and skin conductance were measured after each presentation. The magnitude of the response on the 17th trial increased proportionally to the degree of difference between the habituated color stimulus and the test color stimulus. Although they did not employ the neuronal model in their discussion of the results, the results could be interpreted in this way.

McCubbin and Katkin (1971) did a similar study but found conflicting results. They gave their subjects eight presentations of a standard stimulus and then presented them with one of four novel stimuli. They found no difference in skin conductance magnitude to the test stimuli as a function of the difference between stimuli. Similar results were also obtained

by Frith and Connolly (1978). They suggest that a specific neuronal model might not exist, but rather a similar representation that would possess characteristics of the habituated stimulus. Therefore. if the test stimuli are not sufficiently different from the habituated stimulus, then differential response patterns might not be expected (Frith and Connolly, 1978, p. 554).

Öhman's (1979) theory of the orienting response's relation to information processing has led the way in current conceptions on this topic. Öhman states that there are four components to information processing. They are the: (1) pre-attentive mechanism, (2) central channel, (3) short-term memory store, and (4) long term memory store (Öhman, 1979, p. 444-446) (see fig. 1). Öhman's model is very similar to Atkinson and Shiffrin's, with two important exceptions. First, Öhman suggests that the short-term store is contained within the long term store, rather than seeing them as separate components. Second, he proposes the existence of a central capacity-limited channel where short-term memory processing occurs. Therefore, the short-term store is nothing but a store for the information that is being processed by the central channel.

The long-term memory store, which has a very large capacity (perhaps infinite), contains representations of past events, experiences, knowledge, and skills. The information held here is in a passive state and cannot be acted upon unless it is transferred into the short-term store. Attributes of a stimulus

as well as the context in which it occurs are hierarchically stored in what Öhman terms control elements. Learning involves establishing associations between these stimulus control elements. The formation of these associations requires the use of the central channel.

The short-term store is built up by activated control elements from the long-term store. There are two functions that the short-term store serves. The first is to set up a selective window to the long-term store. The short-term store builds up and maintains a representation of the person's immediate environment and anything that has happened in the past one to two minutes.

> Thus, because the context is an important attribute of the control elements in the LTS (Estes, 1973), contextual retrieval cues revert hierarchies of control elements from their passive residence in LTS to form parts of STS (Öhman, 1979, p. 447).

The second function of the short-term store is to provide a working space for central processing, allowing for temporary storage and manipulation of information. This is the part of the short-term store that is sharply capacity-limited. Information is maintained in the short-term store throughout central processing. Information decays in the short-term store quickly, and only a small amount of information can remain over an extended period of time. The rate of decay in the short-term store is affected by two factors. First, the rate of decay is fastest for minimally processed information and, second, when many similar control elements are activated and occupy the store

at the same time. Because the short-term store is just a subset of the long-term store, similar organizational principles apply. The difference is that the storage system is set up in the short-term store and then transferred to the long-term store for permanent storage.

Öhman describes the preattentive mechanism as the mechanism which results in an automatic and relatively complete identification of the stimulus, including both its complex features and semantic meaning. The preattentive processes interacts with the short-term store by matching the elements of the stimulus (i.e. such things as color, complexity, context) with the control elements stored in the short-term store. These processes themselves do not require any allocation of central cognitive resources. Rather, this operation is carried out exclusively between the preattentive mechanism and the short-term store. The purpose of these automatic processes is to save the available resources of the central channel. It is when the preattentive process fails to handle a stimulus on its own that the central channel is called. Öhman states two rules that govern whether or not the central channel is called. The first is when a mismatch occurs between the stimulus and the existing control elements in the short-term store. In this case the central channel is called on to take the stimulus and set up a control element and store it in the short-term store. The other case in which the central channel is called is when a match is made between the stimulus and the short-term store but that

stimulus has been primed as significant.

The last component of this model is the central channel. The more times the central channel is called to process a stimulus, the more cognitive effort that is required. More cognitive effort leads to a greater chance for the stimulus representation to pass into the long-term store. This implies that we learn the most from novel stimuli, for stimuli that already match a representation in the short-term store would fail to be processed in the central channel and thus not get passed into the long-term store. This idea can be seen when one considers rehearsal. Rehearsal involves the repetition of a stimulus that can either be directed at maintaining the control element in the short-term store or storing it in the long-term store. When several new stimuli are encountered in a given context, priority is given to those stimuli that are motivationally significant because of biological needs, previous learning, or instructions.

When the central channel receives a call because of a mismatch, a search begins to compare the stimulus with already existing memory structures in the short-term store. If the state of mismatch continues, new information will be retrieved from the long-term store until the central channel forms a representation of the stimulus in the short-term store. At this point mismatch will no longer occur, and the call to the central channel will stop.

If the central channel is called because the stimulus has

been primed as significant, the stimulus enters into the central channel for appropriate processing and action. Depending on the significance of the stimulus, more or less processing will be required. If a simple and overlearned plan is called for, then little processing will be required. In this case the preattentive mechanism may take over, process the stimulus itself, and execute the required action. However, if as stimulus demands difficult decision processes, then more elaborate processing will be required (Öhman, 1979, p. 446-452).

How does the orienting response fit in with all of this? Stimulus memory mismatch and stimuli primed as significant activate the path between the preattentive mechanism and the central channel. The immediate effect of this is a reallocation of processing resources to analyze the stimulus. This general increase in activation is identified with an orienting response. The orienting response improves the quality of information to the central channel by increasing arousal and thus enhancing attention (Öhman, 1979, p. 453). The magnitude and probability of the orienting response is determined by whether or not a matching control element is available in the short-term store. The first presentation of a novel stimulus will most likely elicit an orienting response. Further presentations will enable the central channel to construct a control element that will eventually match the presented stimulus and then pass the control element to the long-term store. If that stimulus is encountered again, then the short-term store will only have to recall the

control element for that stimulus from the long-term store for a match to occur (Öhman, 1979, p. 455-466).

One last important aspect of this theory is the relation of intense stimuli to habituation. Öhman's proposition is that an intense stimulus leads to a faster rate of habituation. He states that because an intense stimulus elicits an intense orienting response. Thus, intense stimuli are given more processing resources. This leads to the more rapid development of an accurate control element and thus more rapid habituation. This is different from Sokolov's proposition that an intense stimulus would take longer to habituate. Öhman describes two types of habituation. If one looks at trials to habituation, then results similar to those which Sokolov predicts would be expected. However, if habituation is measured as the amount of change from initial to steady-state responding, the relationship that Öhman hypothesizes would be expected (Öhman, 1979, p. 458). Thus, their distinct predictions reflect different criteria of "faster habituation."

Öhman elaborated Sokolov's neuronal model. He has proposed the existence of control elements that form the representative model that the stimulus is constantly being compared with. He adds the idea of stimulus significance to his model. In this case, unlike Sokolov, Öhman divides the possibility of an orienting response into two cases, novel and significant, and describes why a stimulus primed as significant would come to elicit an orienting response.

Research Supporting Öhman's Model

Several studies have supported the model that Öhman proposes. Dawson, Beers, Schell, & Kelly (1982) used a classical conditioning paradigm with a tone as the conditioned stimulus and an electric shock as the unconditioned stimulus. There was a 7-second delay between the conditioned and unconditioned stimuli. After the conditioned stimulus, they presented their subjects with a tone 300, 500, 3500, 6500, or 7500 milliseconds later, to which the subjects were instructed to react. The slowest reaction times occurred when the imperative stimulus was 300 milliseconds after the conditioned stimulus. Subjects who showed large electrodermal responses exhibited significantly longer reaction times at 300 milliseconds than small electrodermal responders. The first result can be interpreted in Öhman's theory by hypothesizing that subjects are still processing the conditioned stimulus at 300 milliseconds and thus cannot process the reaction stimulus efficiently. The second finding is also evidence for Öhman's theory. It supports the notion that a large electrodermal response is a signal of deeper processing. Thus, a large response implies more in-depth processing of the first stimulus and thus less processing is available for the signal stimulus. This is evidenced by slower reaction times.

Siddle, Remington, Kuiack, & Haines (1983) reported a study that shows further evidence for this model. They presented their subjects with 15 presentations of a snake slide (stimulus one) followed by one second of 65 or 105 dB white noise (stimulus

two). On the sixteenth trial they omitted stimulus two and measured the magnitude of skin conductance. They represented it on trial 17 and measured skin conductance once again. They then compared the magnitude of the response to stimulus two on trials 16 and 17. First, they found that the frequency and amplitude of the response was a positive function of stimulus two intensity. They also found that responding to stimulus one on re-presentation was reliably higher than pre-omission. These results support Öhman's model of priming and of control elements because the repeated presentation of stimulus one with stimulus two may have led to the priming in the short-term store by stimulus one. In this way, a control element was set up between stimulus two and stimulus one. Omission of stimulus two is a surprising event in that, on trial sixteen, stimulus one did not predict stimuli two. On the re-presentation trial stimulus one primes stimulus two less effectively, and thus stimulus two is more elaborately processed (Siddle et al., 1983a).

Siddle (1985) found very similar results to those of Siddle et al. (1983a). On omission trials, he presented subjects with either a novel stimulus, an experimentally familiar stimulus, or no stimulus. When subjects received either no stimulus or the novel stimulus, this led to dishabituation (increased responding), whereas the familiar stimulus did not lead to increased responding. Priming theory did not lead to increased responding. Thus, omission or novelty was not primed and led to increased processing demands. In the case of the experimentally

familiar stimulus, it was already primed and thus was not interpreted as surprising and in need of additional processing (Siddle, 1985). Siddle and Hirschorn (1986) report identical results in a replication of the experiment by Siddle (1985).

The Issue of Stimulus Complexity

When one uses Öhman's Priming model as a theoretical framework for discussing the orienting response, stimulus complexity can easily be related to the OR. Because there are more components to a complex stimulus (i.e., more lines on the screen, more tones in an auditory stimulus pattern, etc.), the control element for a more complex stimulus will take longer to form. If the call to the central channel (where the stimulus will be processed) is signaled by an orienting response, several response patterns could be predicted. First, habituation of the OR to complex stimuli should take more trials than to less complex stimuli. This is because for a less complex stimulus, the central channel can build the control element and transfer it to the short-term store sooner. Because it builds the control element sooner, calls to the central channel will end sooner than if the stimulus were more complex.

A second prediction that follows from Öhman's theory is the relation between the magnitude of the OR relative to stimulus complexity. Because the orienting response is seen as increasing arousal levels for more effective processing, a more complex stimulus should elicit an OR of greater magnitude than that elicited by a less complex stimulus. For a complex stimulus to

be more efficiently processed, more processing resources are required. This would be reflected in an OR with a larger magnitude. The more complex stimulus contains more elements, thus increasing the amount of attentional resources that need to be devoted to the stimulus. This in turn leads to the control element forming sooner, and the call to the central channel will be made fewer times. The greater the magnitude of the OR, the faster the rate of habituation. Likewise, the smaller response magnitude, the longer the habituation takes. This can be predicted as follows: the greater magnitude OR signals a higher sense of arousal, which leads to a heightened perception of the stimulus. This heightened perception leads to a control element forming sooner and thus fewer trials to habituation results. On the other hand, a smaller magnitude OR leads to less efficient processing, thus resulting in more trials to habituation. This, however, does not mean that more complex stimuli will have faster habituation rates. Simple stimuli may take as little as one presentation to form a representative control element. More complex stimuli may require several presentations for an accurate control element to form. However, those subjects who have larger initial responses to a complex stimulus may have faster habituation rates when compared to those who have smaller initial responses to the same stimulus.

Even though the above hypothesis seem reasonable, there is little empirical support. McCubbin and Katkin (1971) found results contradictory to these hypotheses. They presented their

subjects with a standard stimulus until habituation had occurred. At that point they presented one of four test stimuli, each varying to some degree from the standard stimulus. This test stimulus was followed by repeated presentations of the standard stimulus. They measured the response to the standard stimulus after the test stimulus had been presented.

They predicted that the degree of dishabituation to the re-presentation of the standard stimulus should be a function of the degree of difference between the test stimulus and the standard stimulus. In particular, the larger the difference between the two stimuli, the greater the difference in control elements. The test stimulus, in a sense, disrupts the current control element, and a new control element is constructed for the test stimulus. When the standard stimulus is re-presented after a very different test stimulus, what it is being compared to is very different, thus mismatch occurs and an OR is elicited. In the case where the test stimulus is similar to the standard, the control element is not significantly altered, and the re-presentation of the standard stimulus is matched to an already existing, relatively similar control element. Thus only a small OR, if any would be elicited.

Their results, however, contradicted this theory. They found no differential dishabituation as a function of the degree of difference between the standard and the test stimuli. No matter what the degree of difference, the experimental groups responded the same. Connolly and Frith (1978) report similar

findings. They found no difference between habituation rates as a function of stimulus complexity (their term--information). Groups which received highly complex stimuli showed the same rates of habituation as groups which received low complexity stimuli.

Berlyne et al. (1963) show clear support for the notion that highly complex stimuli elicit more OR's than less complex stimuli. Germana (1968) also found support for this hypothesis. Germana found that the level of OR response habituation across trials was a direct function of the amount of information the stimulus conveyed. He also found that the overall level of the OR was a positive function of the amount of information the stimulus conveyed.

All the above studies attached a significance to the presented stimuli. McCubbin and Katkin (1971) told their subjects to remember the presented stimuli. Likewise, Connolly and Frith (1978) told their subjects that they would be required to recognize the stimuli after the experiment in a recognition task. As already stated, Berlyne et al. (1963) only found their supporting results when subjects were told that they would later be required to recognize the presented stimuli in a recognition task. Finally, Germana (1968) found his greatest effects when subjects were required to respond behaviorally to the presented stimulus.

According to Öhman, an orienting response is determined by one of two conditions: (1) stimulus mismatch between the

perceived stimulus and the control element or (2) a stimulus that has been primed as significant and thus requires further processing so that some course of action can be taken. It can be argued that the above studies did not measure complexity at all. Differential response patterns would not be expected to complex stimuli that have been primed as significant. Response patterns are determined by the significance attached to the experimental stimuli only.

In conclusion, numerous studies show evidence for different components of Öhman's model. Frith & Allen (1983) and Goldwater (1977) show support for the notion that stimuli increase arousal and thus allow more stimuli to be processed. In this way more elaborate control elements can be formed so that a more efficient processing of the environment can occur. Siddle (1985), Siddle et al. (1983a.), Siddle & Hirschorn (1986), Dawson et al. (1982), Spinks, Blowers, & Shek (1985), Siddle & Kroese (1985), Connelly and Frith (1979), McCubbin and Katkin (1971), Germana (1968), and Berlyne et al. (1963) all show support for Öhman's hypothesis of priming and the notions of significance and stimulus mismatch in the elicitation of the orienting response.

Given the numerous studies listed above which lend support to Öhman's priming theory, the equivocal results found when stimulus complexity is investigated are puzzling. As explained earlier, the relationship between stimulus complexity and OR elicitation should be easily predicted given Öhman's theoretical framework. Previous studies however have confounded response

elicitation as the result of significance and response elicitation as the result of mismatch (McCubbin and Katkin (1971), Connolly and Frith (1978), Berlyne et al. (1963), Germana (1968)). Recall that OR elicitation is the result of one of two processes; either the stimulus is primed as significant (as the case was in the above studies) or stimulus mismatch occurs.

The experiment reported here involved two groups of subjects. Group 1 received 4 presentations of a grid-shaped template stimulus, one presentation of a dishabituating stimulus (herein referred to as the disrupter stimulus) composed of a single horizontal bar from the grid, and finally another representation of the grid. Group two had the same series of events but the template stimulus was the horizontal bar and the disrupter stimulus was the grid. The dependent variable was electrodermal activity.

The purpose of the following study is to investigate the relationship between stimulus mismatch and orienting response elicitation without the confound of significance. From the theoretical implications of Öhman's model it was predicted th

1. The mean response magnitude to trial 1 in condition one would be larger than the mean response magnitude to trial 1 in condition two. Likewise, the probability of a response to trial 1 in condition one would be greater than the probability of a response to trial 1 in condition two.
2. The mean response magnitude to trial 5 in condition

one would be less than the mean response magnitude to trial 5 in condition two. Similarly, the probability of a response to trial 5 in condition one would be less than the probability of a response to trial 5 in condition two.

3. The mean response magnitude to trial 6 in condition one would be less than the mean response magnitude to trial 6 in condition two. Finally, the probability of a response to trial 6 in condition one would be less than the probability of a response to trial 6 in condition two.

Methods

Subjects

The participants were 22 Introductory Psychology student volunteers (12 males and 10 females) who participated in the following experiment (after giving signed consent) for course credit. All participants that came to the lab for the experiment participated. There were no refusals. Participants were assigned randomly to one of two experimental conditions with two restrictions; one, each condition in the end would have the same number of participants, and second, the same number of males and females were in each condition.

Apparatus and Recording

Two different stimuli were presented. The dimensions of the stimuli were as follows. The grid was a tic-tac-toe board composed of four lines, each 12 cm. long, spaced four cm. apart. The horizontal bar stimulus was the upper bar of the grid and was thus 12 cm. long. Stimuli were generated using custom software. The monitor on which the stimuli appeared was an Amdek Video-300 amber computer monitor.

For skin conductance recording, the volar surfaces of the middle segment of the first and second digits of the nonpreferred hand were lightly rubbed with distilled water and then dried. Second, a unibase solution was wiped on the same digits and wiped off. Beckman standard Ag-AgCl electrodes were then attached with unibase paste as the electrolyte.

Skin conductance was monitored on a Grass Model 7 polygraph.

Responses were recorded with a Cerebral Electronics Skin Conductance Coupler, which supplied a constant .5 volt. A Grass 7DAC driver amplifier was used for the SC channel. Skin conductance was digitized on-line at 20 Hz by an LSI-11/73-based Pearl IIb microcomputer with a resolution of .0083 uhmos per A/D unit.

Procedure

Participants were seated in a comfortable reclining chair in an upright position in a quiet room. Average room temperature was 32.9 C with a range of 31.1 C to 35.4 C. The computer monitor was placed in front of the participant approximately 125 cm from the eyes. The stimulus equipment and recording apparatus were located in an adjoining room.

After hooking up the participant to the polygraph, a standard set of instructions (see appendix) was read explaining the procedure and what was required of the participant during the session. The participant was told that the study was designed to investigate physiological responses to visual stimuli. No specific action would be required of the them. Rather, they were to relax and pay attention to the stimuli that would be appearing shortly. Following these instructions and the fielding of any questions, the participant was asked to relax until told via intercom when the experiment would begin. Overhead lights were turned off, and a small study lamp, located out of the participant's direct field of vision, was turned on. The door was then shut. Subsequently, there was a short rest period while

the instruments were properly calibrated.

After polygraph calibration was complete, the participant was informed via intercom that the experiment was about to begin. Once again, they were reminded to relax and pay attention as the various stimuli appeared on the screen. A baseline measure was taken for 10 secs. after which the stimulus presentations began. Conditions one and two were composed of six visual stimuli presentations. For condition one, participants were presented the tic-tac-toe grid on trials 1 through 4 and 6. Trial 5 was the dishabituating horizontal bar. Each stimulus remained on the monitor for 800 ms. Inter-trial intervals (ITI; onset to onset) were varied randomly from 11 to 19 seconds with a mean ITI of 15 seconds. Those participants assigned to condition two received the same sequence of events, with the stimuli reversed (the tic-tac-toe grid was the dishabituating stimulus).

At the end of the session, the participant was informed via intercom that the experiment was over. The experimenter then entered the room and took the sensors off the participant. At that point the participant was debriefed and allowed to leave.

Data Reduction and Analysis

Raw skin conductance data were smoothed with a 19-weight, non-recursive, 0-2 Hz bandpass filter prior to scoring.

Skin conductance responses (SCRs) to stimulus onset were computer scored using an automated algorithm with manual override. The algorithm scored a response as present if the following criteria were met: (a) onset between 1 and 4 seconds

after stimulus onset, (b) amplitude of at least .05 uhmos sustained for at least .5 seconds, and (c) peak reached within 5 seconds of onset.

Descriptive statistics (mean and standard deviation) were computed for SCR magnitude on trials 1 through 6 for each condition. A two tailed t-test for differences between inde; ndent measures was used to test for a significant difference between the mean response magnitude on trials 1, 5, and 6 for condition one and these same trials for condition two. Fisher's Exact Z was computed to determine if the probability of a response to trials 1, 5, and 6 significantly differed across conditions.

Finally, Fisher's Exact Z was computed to test if a response to trial 6 was dependent on a response to trial 5 for both conditions combined.

Results

A rejection region of $p < .05$ was used throughout. Table 1 shows mean and standard deviation of SCR magnitude (uhmos) for condition one. Identical information for condition two is found in Table 2. Table 3 shows the number of responders to each trial by condition. Table 4 shows the proportion of responders to each trial by condition.

T-tests revealed no significant differences between the response magnitudes on trials 1, 5, and 6 in condition one and trials 1, 5, and 6 in condition two. Trial 1 in condition one did not elicit a significantly larger response than trial 1 in condition two ($t(20) = +/-.33$, not significant) (see fig. 2). Contrary to the hypothesis, trial 5 (dishabituation) in condition two did not elicit a significantly larger response than trial 5 in condition one ($t(20) = +/- 1.7$, not significant) (see fig. 3). Similarly, the comparison between mean magnitude on trial 6 in condition one and trial 6 in condition two did not yield a significant difference. In this case trial 6 in condition two was not significantly greater than trial 6 in condition one ($t(20) = +/-.09$, not significant) (see fig. 4).

When the magnitudes to identical stimuli were compared between conditions, the results were equivocal. The mean response magnitude to the horizontal bar (trial 5) in condition one was significantly smaller than the magnitude to the horizontal bar (trial 1) in condition two ($t(20) = +/-2.38$, $p <$

.05). This finding is apparent in figure 5. However, the mean response magnitude to the grid (trial 1) in condition one was not significantly larger than the mean response magnitude to the grid (trial 5) in condition two ($t(20) = +/-1.86$, not significant) (see fig. 6). Therefore, the horizontal bar elicited a significantly larger response when it was presented on trial 1 than when it is presented on trial 5. This however was not true for the grid.

A Fisher's Exact test suggested that there were no differences between conditions in the probability of responding to trial 1 ($p = .24$, not significant) (see Table 4). Contrary to the hypothesis, there was no significant difference in the probability of a response to trials 5 or 6 between conditions as well. The probability of a response to trial 5 in condition one was not significantly less than the probability of a response to trial 5 in condition two. ($p = .25$, not significant) (see Table 4.). Similarly, the probability of a response to trial 6 in condition was not significantly greater than the probability of a response to trial 6 in condition two ($p = .7618$, not significant) (see Table 4). Finally, a response to trial 6 was not dependent on a response to trial 5 for both conditions combined ($p = .481$, not significant).

After a preliminary analysis of the data, it was noted that all those participants who responded to trial 5 had responded to trial 1. A response to any other earlier trial did not predict a response to trial 5. This led to two further analyses of the

data. The first involved the relationship between a response to trial 1 and a response to trial 5. The second involved a separate analysis for those six subjects who responded to trials 1 and 5. The rationale for the analysis of these six subjects is the distinction between mean response amplitude and mean response magnitude discussed by Venables and Christie (1980) and how responses scored as 0 should be analyzed. Based on their suggestions, an analysis was done on only those participants who had a scoreable response on trials 1 and 5 to further assess the relationship between a response to these two stimuli.

Table 5 presents the mean and standard deviation of SCR amplitude (uhmos) for condition one. Identical information for condition two is found in Table six.

A Fisher's Exact test was computed to determine if a response to trial 5 was dependent on a response to trial 1. For condition one a response to the horizontal bar (trial 3) was not dependent on a response to the grid (trial 1) ($p = .51$, not significant). However, for condition two, a response to the grid (trial 5) was dependent on a response to the horizontal bar (trial 1) ($p = .046$, significant). When both conditions are combined, trial 5 response did seem to be dependent on a response to trial 1 ($p = .04$, significant).

For the six participants analyzed separately, a t-test revealed that the mean response amplitude to trial 1 in condition one was not significantly larger than the mean response amplitude to trial 1 in condition two ($t(6) = +/-.7728$, not significant)

(see fig. 7). However, the mean response amplitude to trial 5 in condition one was significantly less than the mean response amplitude to trial 5 in condition two ($t(6) = +/-2.9$ $p < .05$) (see fig. 8).

As was found in the magnitude data when identical stimuli were compared, there was a significant difference between conditions for the horizontal bar. This finding was not true for the grid. The mean response amplitude to trial 1 in condition two was significantly larger than the mean response amplitude to trial 5 in condition one ($t(6) = 27.20$, $p < .001$) (see fig. 9). However, the mean response amplitude to trial 5 in condition two was not significantly less than the mean response to trial 1 in condition one ($t(6) = +/- .41$, not significant) (see fig. 10). Thus, the first presentation of the horizontal bar elicited a much larger response when it occurred on trial 1 (condition two) than when it occurred on trial 5 (condition one). This finding was not found for the grid.

Discussion

The purpose of this experiment was to investigate the role stimulus complexity has on the elicitation of the orienting response. In particular, the relationship between stimulus complexity and Öhman's priming theory was investigated. Öhman proposed the existence of four structures in memory: (1) the pre-attentive processes, (2) short-term memory, (3) the central channel, and (4) long-term memory (see fig. 1). He suggested that the elicitation of the orienting response was dependent on one of two conditions; either there is a mismatch between the presented stimulus and a stimulus already represented in short-term memory, or the presented stimulus has been primed as significant in the short-term memory. If either condition is met, a call to the central channel for further processing will be made and an orienting response is elicited (Öhman, 1979). Research in the past has been equivocal in evaluating this model of the role of stimulus complexity.

The purpose of this study was to investigate more fully mismatch between a presented stimulus and one represented in short-term memory. The template stimulus is the stimulus that is currently stored in short-term memory. It is herein called a template stimulus, because, after repeated presentations of the stimulus, a template forms in short-term memory (built of control elements) to which other stimuli will later be compared. In this study the tic-tac-toe grid was the template for condition one,

and the horizontal bar was the template for condition two. The disrupter stimulus is a novel stimulus (novel to the situation) that does not match the template stimulus and thus disrupts the matching process (this is often referred to as the dishabituating stimulus). The horizontal bar was the disrupter in condition one and the grid was the disrupter in condition two.

The existence of template formation is evidenced by tables 1 and 2. Both show the decreasing number of responses per trial by condition. As the stimulus is presented repeatedly, a more accurate representation of the stimulus forms in short-term memory until mismatch no longer occurs. At this point a match exists and there is no reason for a call to the central channel. Thus, the orienting response is no longer elicited.

Three main hypotheses were tested in this experiment. The first was that the mean response magnitude to trial 1 in condition one would be larger than the mean response magnitude to trial 1 in condition two. Because no description of the stimulus was given prior to presentation, a participant began this experiment without a template for trial 1. The more complex stimulus (the grid) should elicit a larger OR than the simple stimulus (the bar), because more processing resources are required to build an accurate control element. However, this was not the case (see fig. 2). The mean magnitude of a response to trial 1 in condition one was not significantly larger than the mean magnitude of the response to trial 1 in condition two.

It was also hypothesized a response to trial 1 in condition

one (the grid) would be more likely to occur than the response to trial 1 in condition two (the horizontal bar). According to this theory, the probability of a response is determined by mismatch between template and disrupter. Because there is a greater degree of mismatch between the grid and the blank template than between the horizontal bar and the blank template (a difference of four axes versus one), the probability of a response to trial 1 should be greater for condition one than condition two. Contrary to this hypothesis, no significant difference was found between the probabilities of a response to these two stimuli (see Table 4).

The second hypothesis was that the mean response magnitude to trial 5 in condition one would be less than the mean response magnitude to trial 5 in condition two. Because the bar is presented on the screen precisely where an axis of the grid had previously been, it becomes a subset of the grid. Therefore a control element for this stimulus should already exist. In condition two, however, when the grid was presented on trial 5, three new axes were added to the screen. Therefore more processing should be required and this would be reflected in a larger orienting response. Likewise, the probability of a response to trial 5 in condition two should be greater than the probability of response to trial 5 in condition one, because the degree of difference between trials 1 and 5 in condition two is greater than that in condition one. Once again the results suggested otherwise. Neither the magnitude (see fig. 3) nor the

probability (see Table 4) significantly differed between conditions.

Finally, the third hypothesis concerned trial 6. It was hypothesized that the mean response magnitude to trial 6 in condition one would be less than the mean response magnitude to trial 6 in condition two. Because trial 5 in condition one (the horizontal bar) already had a control element built into the template, it should not disrupt the existing template. Therefore, when the grid was re-presented on trial 6, the template to which it was being compared should still exist and thus mismatch should not occur. For condition two, however, the grid should sufficiently disrupt the existing template so that on presentation of the horizontal bar, the template should no longer be the same. Thus, the probability of a response and the response magnitude to trial 6 should both be larger for condition two than condition one. The results also contradicted this hypothesis. There was not a significant difference in the mean response magnitude (see fig. 4) nor in the probability of a response between conditions on trial 6 (see Table 4).

Although five of the six comparisons mentioned above were in the predicted direction (the probability of a response to trial 6 was equal for both conditions), none was significant. Because there were no significant differences in magnitude and probability to trials 1, 5, and 6 between conditions, something other than the number of elements may be involved in determining stimulus complexity. For example, a stimulus with four elements

(the grid) may not be more complex than a stimulus with one (the horizontal bar). What might be important is the degree of difference between the stimulus and the existing template. Given this hypothesis, a stimulus with four components is no more likely to elicit an orienting response than a stimulus with one component. Rather, whichever stimulus differs more from the existing template will have a higher probability of eliciting a response and a higher magnitude. If the degree of difference were the important factor in determining elicitation of a response, then several new hypothesis could be proposed. First, trial 1 in condition one should elicit a larger response and have a higher probability of response than trial 1 in condition two (for the same reasons outlined earlier in the original hypothesis). Second, the mean magnitude and probability of a response to trial 5 should not differ between conditions. Because the degree of difference between trials 1 and 5 is the same for each condition (a difference of three bars), the same type of processing would be required. Hence there would be no difference in response patterns between conditions. Following this logic, if there is no difference in response patterns to trial 5, then one should not expect differential response patterns to trial 6. Because the degree of difference between trials 1 and 5 is the same for both conditions (a difference of three bars), then trial 5 would be equally disrupting to the template in each condition. Thus, if a response to trial six is dependent on a response to trial 5, there will be no difference

in the probability or magnitude of a response to trial 6 between conditions. Except for the similar response pattern on trial 1, (amplitude data for trial 1 also revealed no significant difference), the results support these new hypothesis. There was no difference in the mean response magnitude or probability of response to trials 5 or 6 between conditions.

A similar response pattern to trial 1 for each condition does not compromise the proposed hypothesis. If the stimuli are not described to the participant, then there is no way to control for the preconceptions the participant may have as to the stimuli that are going to appear. Therefore, an infinite variation of templates may exist in the STM of the participant in anticipation to the stimulus. If this were the case, then regardless of the stimulus presented on trial 1, a response would be expected. More importantly, in this paradigm where the two stimuli were not overwhelmingly different, the degree of difference between the first presentation and any preconceived template may be similar for both conditions. In this case differential response patterns would not be expected.

It is also important to consider the difference between the mean response magnitude on trial 1 in condition one and the mean response magnitude on trial 5 in condition two (see fig. 6). This is a comparison of the mean response magnitude for the first time the tic-tac-toe grid is presented. Although this difference is not statistically significant, it is in the predicted direction.

Taken together, the above results provide evidence for the idea that elicitation and probability of a response are not just a function of the number of elements on the screen. Rather it is possible that magnitude and probability of a response could be a function of complexity defined as the degree of difference between template and disrupter. If response magnitude and probability were dependent of the number of components of a stimulus, then differential response patterns to trials 1, 5 and 6 would be predicted between conditions. However, the conditions did not significantly differ on these measures. Therefore, the above discussion provides a degree of support for this new hypothesis of a relative comparison process. Herein is support that the comparison process may be influenced by the degree to which the disrupter stimulus differs from the template stimulus.

Although the study revealed support for this hypothesis, caution must be exercised. Several aspects of the data from this study indicate that response magnitude and probability may be positively correlated with number of components.

A closer look at the mean SCR response magnitudes to trials 1, 5, and 6 when compared across conditions reveals that, even though the mean differences were not significant, two of the three comparisons point more towards the complex stimulus. In other words, two out of three times, the tic-tac-toe grid elicited a larger response than the horisontal bar. It is important to note again that these differences were not significant (see figs. 2 & 3). This was also true for the

amplitude data when trial 5 was compared across conditions. This difference was significant (see fig. 8).

The probabilities of response to different conditions yield similar findings. Although there were no significant differences between the probability of a response to trials 1, 5, and 6 between conditions, there were more responses to the complex stimuli on trials 1 and 5 (see Table 4).

Another important result is the significant difference between the mean response magnitude to trial 5 in condition one and the mean response magnitude to trial 1 in condition two (see fig. 5). These two trials share in common the fact that each is the first time the horizontal bar is presented in the paradigm. One would hypothesize that trial 5 in condition one would elicit a larger OR than trial 1 in condition two, because the degree of difference between template and disrupter is larger in condition one. However, the results indicate otherwise. A similar result was found for the amplitude data (see fig. 9).

One final piece of evidence to consider is the dependency of a response to trial 5 on a response to trial 1. A Fisher's exact test revealed that a response to trial 5 was dependent on a response to trial 1. After further exploring this relationship, it was discovered that it was only true for condition two, not condition one. Since the degree of difference is the same between trial 1 and trial 5 for each condition, the dependency of a response should not differ between conditions. This, however, was not the case.

The above discussion provides a degree of support for the hypothesis of a relative comparison process. The results discussed thus far show evidence for the notion that there is more to response elicitation than complexity of the stimulus. The results of this study suggest that the comparison process is influenced by the degree to which the disrupter stimulus differs from the template stimulus. This study, however, has provided a dilemma for determining what is the important aspect of a stimulus which leads to orienting response elicitation. Although statistically there were no differential response patterns noticed for trials 1, 5, and 6 between conditions (with the exception of trial 5 amplitude between conditions), there was a trend to respond more and elicit larger responses to the more complex stimulus. An important aspect of this study is that differential response patterns were observed even though no significance was attached to the stimuli. This is contrast to results obtained by earlier studies (McCubbin and Katkin (1971); Berlyne et al. (1963); Germana (1968); Connolly and Frith (1978)). Future research needs to be conducted to further explore this relationship between stimulus complexity and template mismatch when significance is not an issue.

Table 1

Descriptive statistics of SCR magnitude (uhmos) for condition one

	Trial					
	T1	T2	T3	T4	T5	T6
X =	.273	.082	.013	.000	.046	.014
std dev. =	.503	.402	.174	.000	.192	.213

Table 2

Descriptive statistics of SCR magnitude (uhmos) for condition two

	Trial					
	T1	T2	T3	T4	T5	T6
X =	.233	.199	.061	.008	.103	.016
std dev. =	.560	.478	.378	.157	.406	.228

Table 3

Number of responses per trial by condition

	Trial					
Condition	T1	T2	T3	T4	T5	T6
1	8	3	2	0	2	1
2	6	3	2	1	4	1

Table 4

Proportion of responses per trial by condition

	Trial					
Condition	T1	T2	T3	T4	T5	T6
1	.73	.27	.18	.00	.18	.09
2	.55	.27	.18	.09	.36	.09

Table 5

Descriptive statistics of SCR amplitude (uhmos) for condition one

	Trial					
	T1	T2	T3	T4	T5	T6
X =	.344	.501	.000	.000	.090	.000
std dev. =	.467	.000	.000	.000	.146	.000

Table 5

Descriptive statistics of SCR amplitude (uhmos) for condition two

	Trial					
	T1	T2	T3	T4	T5	T6
X =	.543	.308	.333	.082	.284	.172
std dev. =	.467	.318	.390	.000	.387	.000

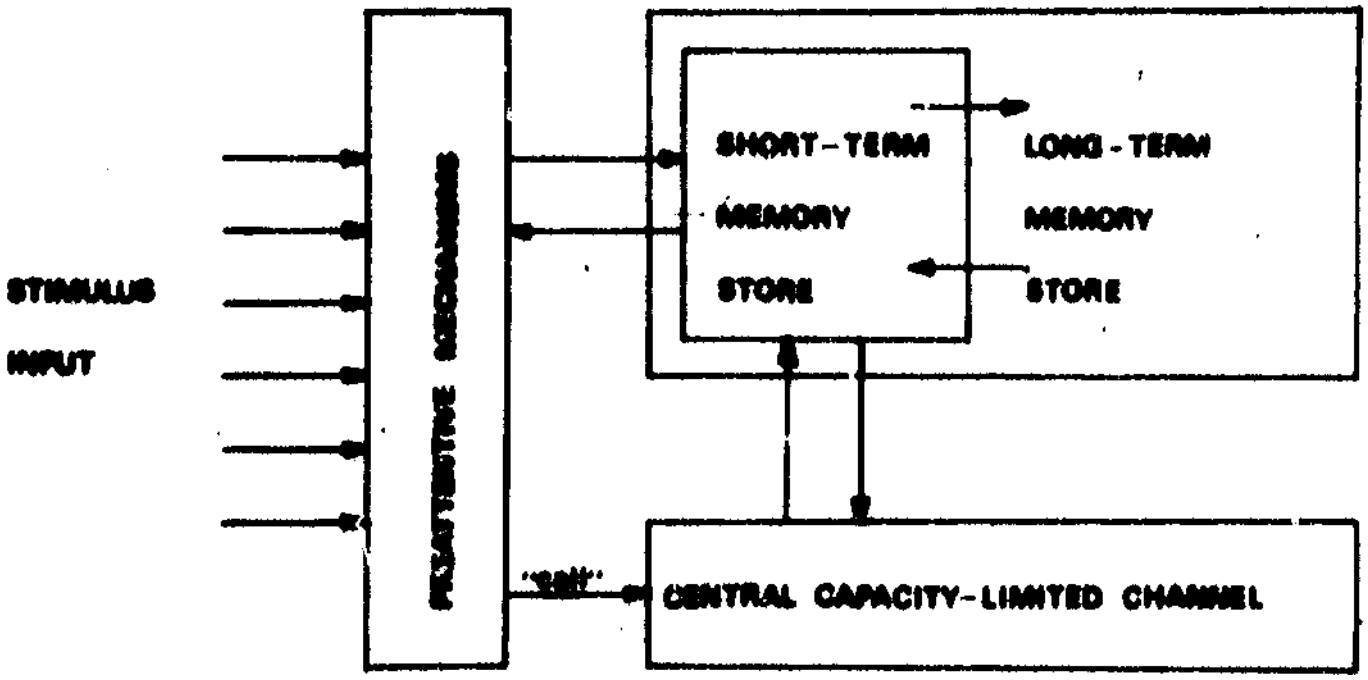

Figure 1. Schematic representation of the hypothetical information processing structures and their interrelations (Öhman, 1979).

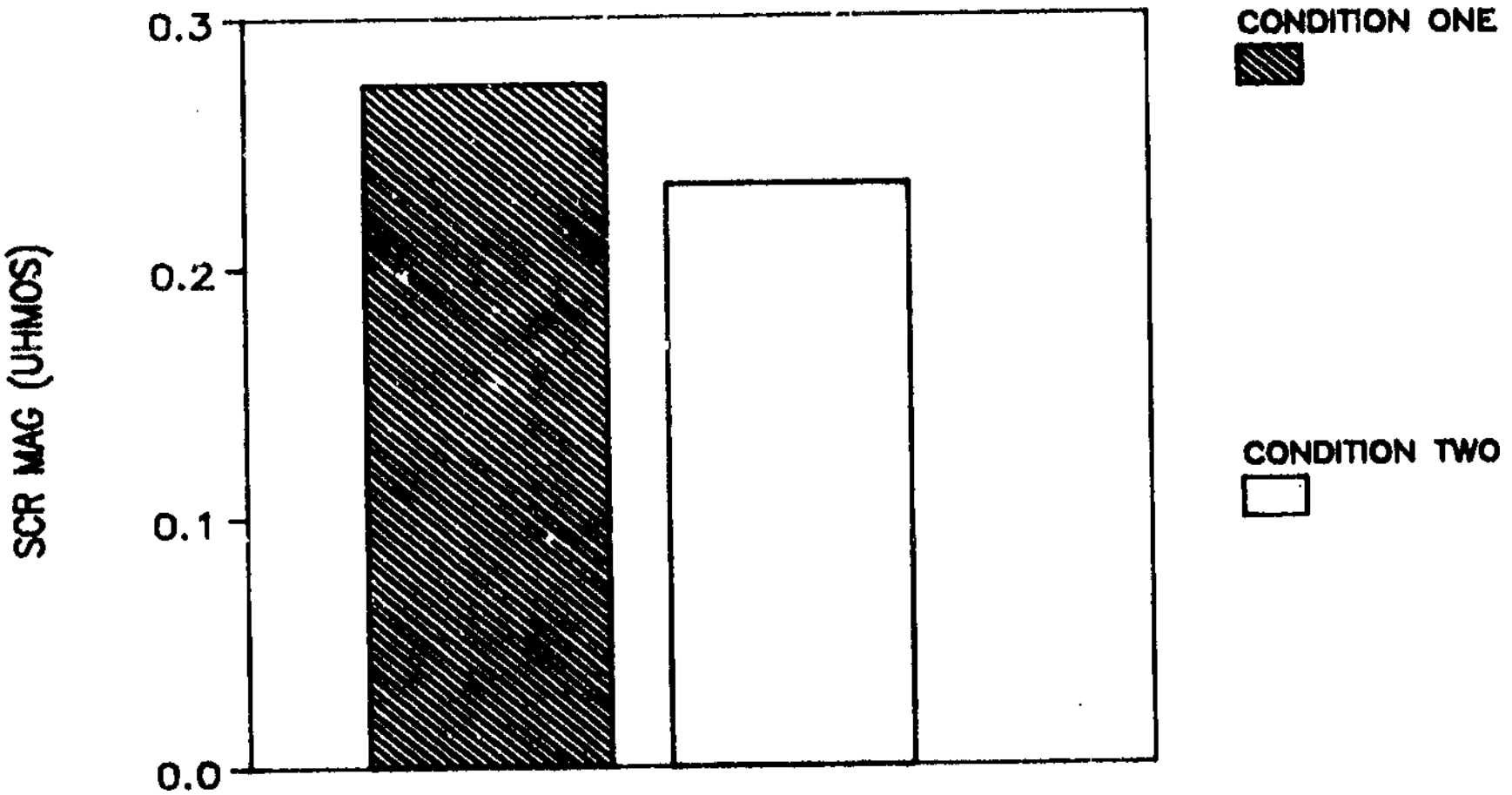

Figure 2. Mean response magnitude (uhmos) to trial 1 by condition (condition one -- grid; condition two -- horizontal bar).

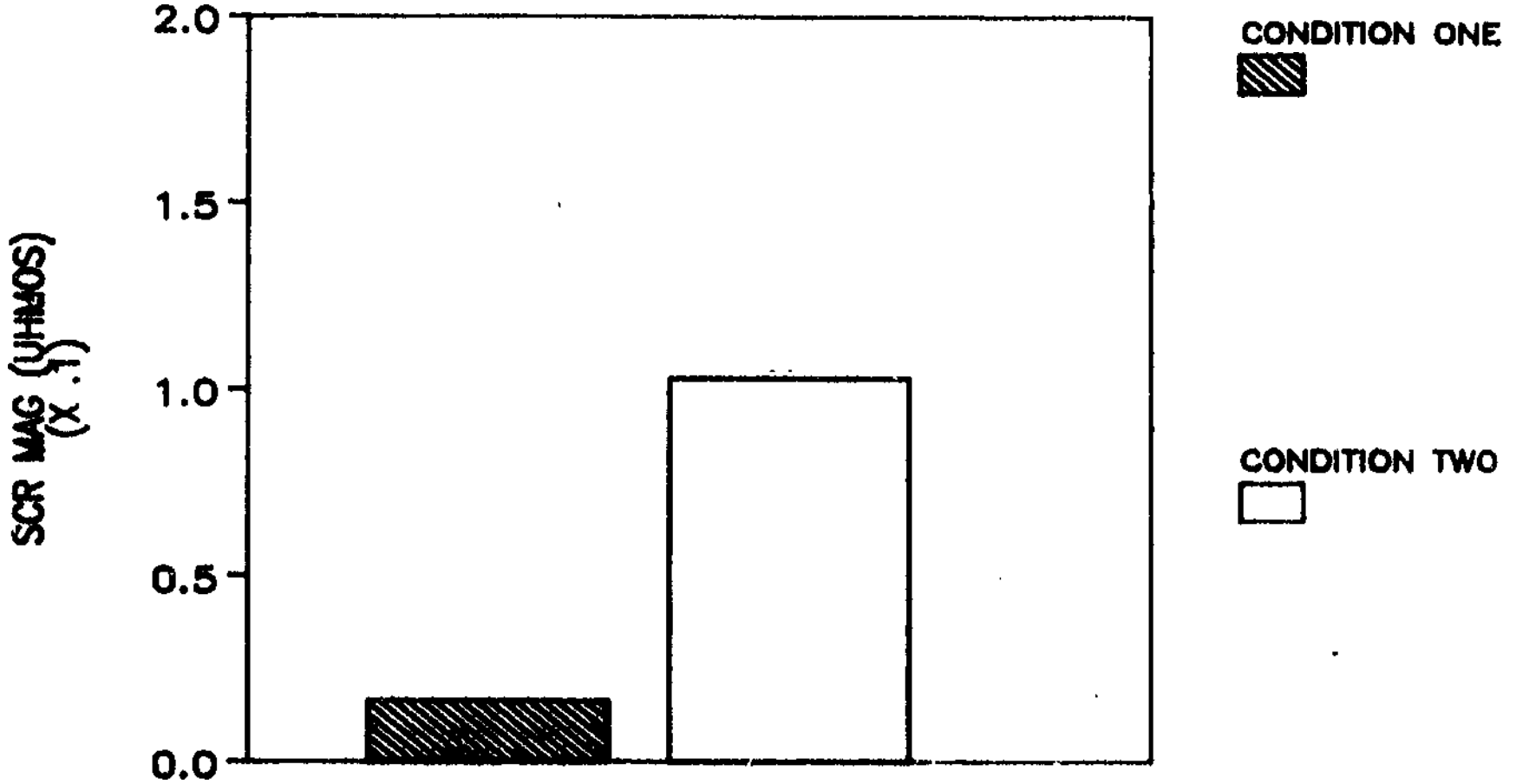

Figure 3. Mean response magnitude (uhmos) to trial 5 by condition (condition one -- horizontal bar; condition two -- grid).

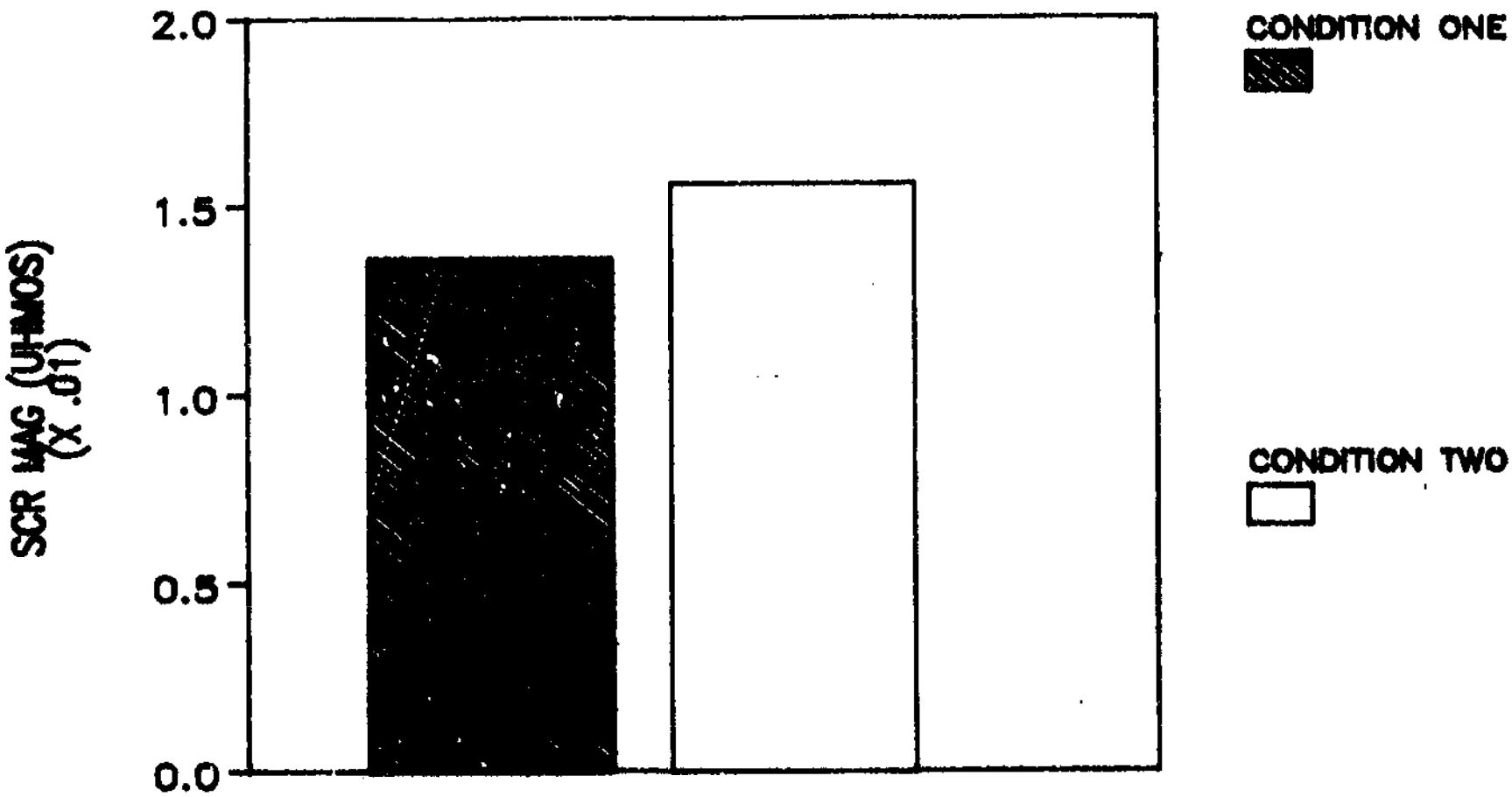

Figure 4. Mean response magnitude (uhmos) to trial 6 by condition (condition one -- grid; condition two -- horizontal bar).

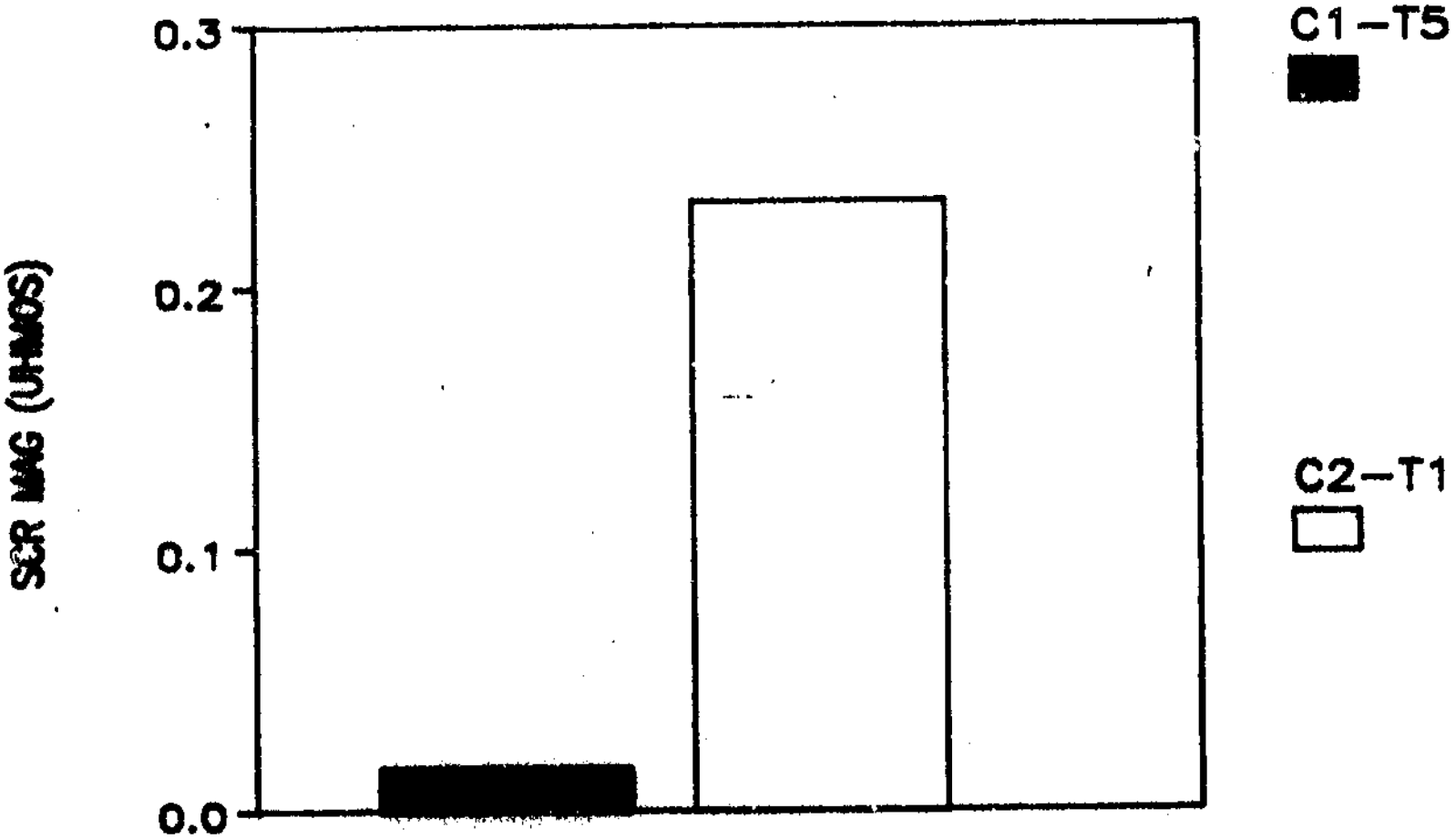

Figure 5. Mean response magnitude (uhmos) to the first presentation of the horizontal bar by condition.

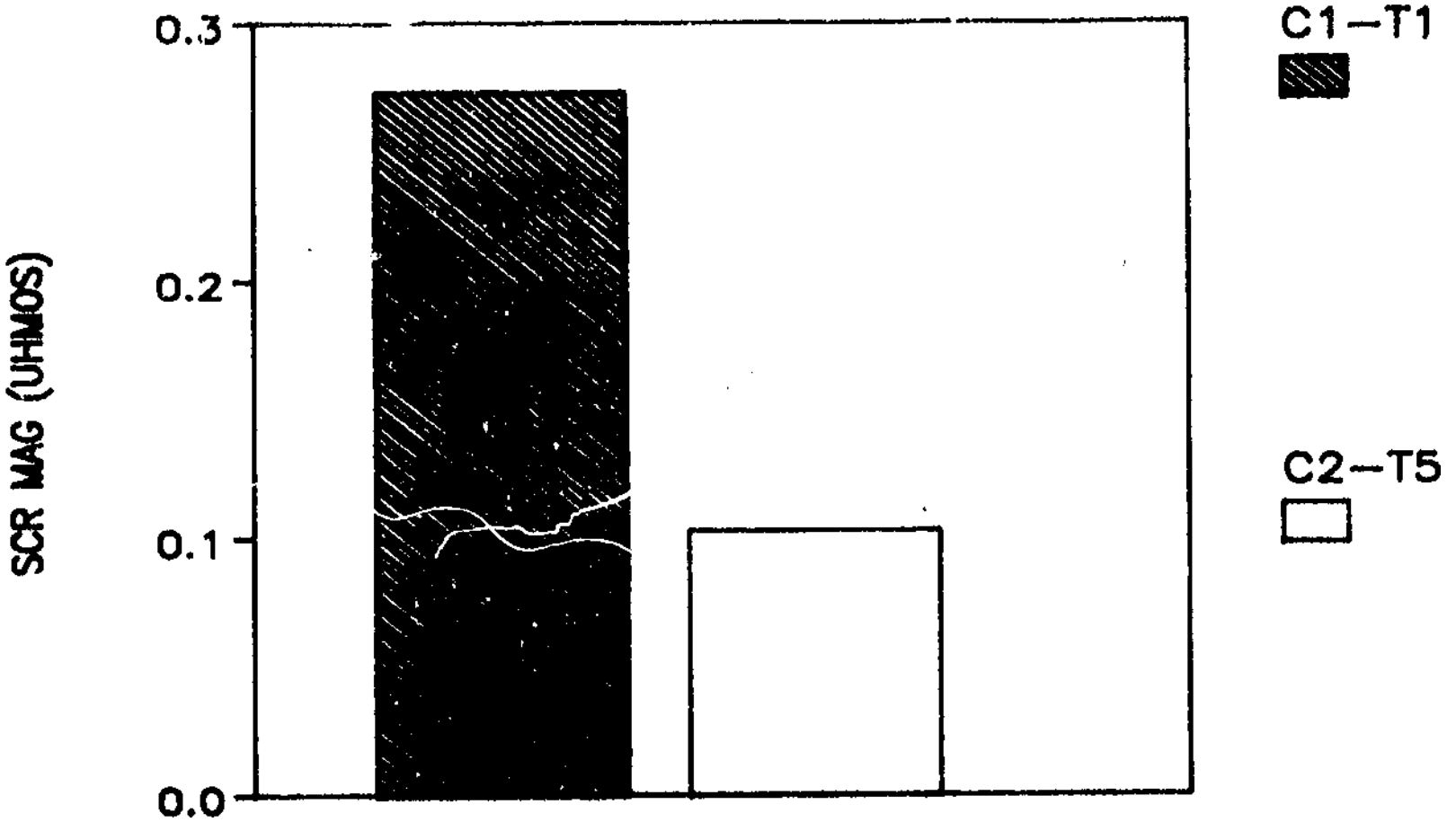

Figure 6. Mean response magnitude (uhmos) to the first presentation of the grid by condition.

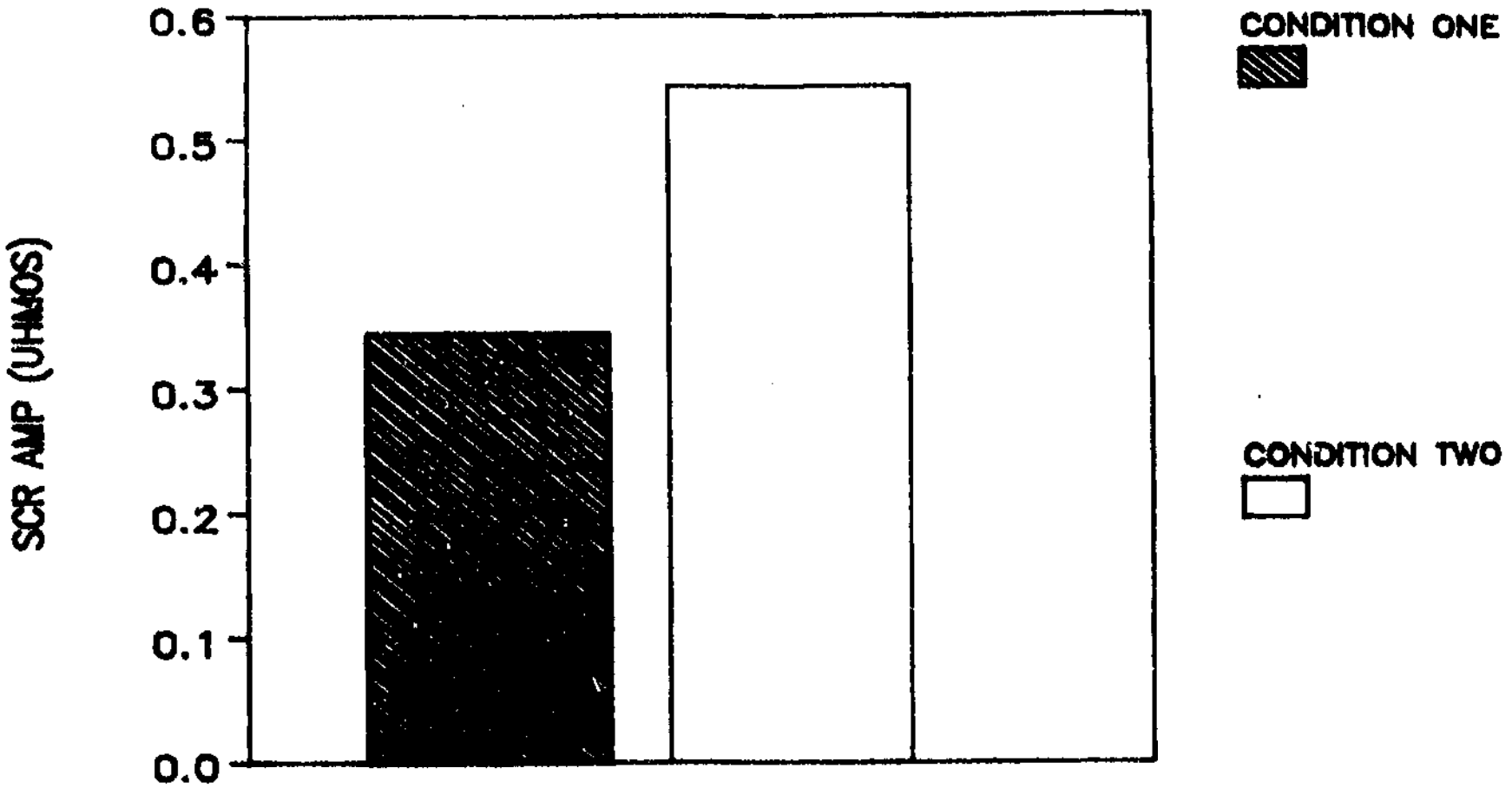

Figure 7. Mean response amplitude (uhmos) to trial 1 by condition (condition one -- grid; condition two -- horizontal bar).

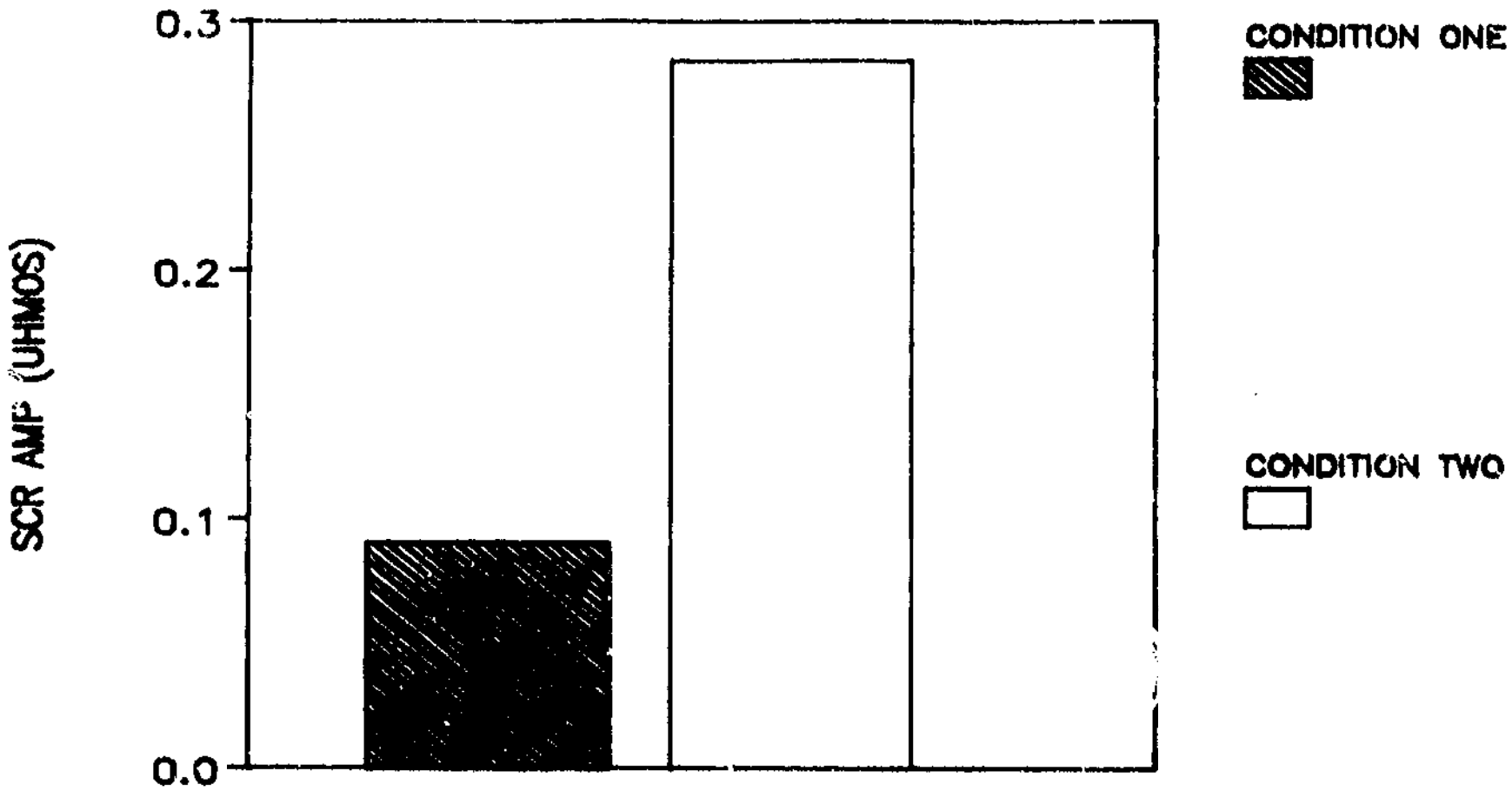

Figure 8. Mean response amplitude (uhmos) to trial 5 by condition (condition one -- horizontal bar; condition two -- grid).

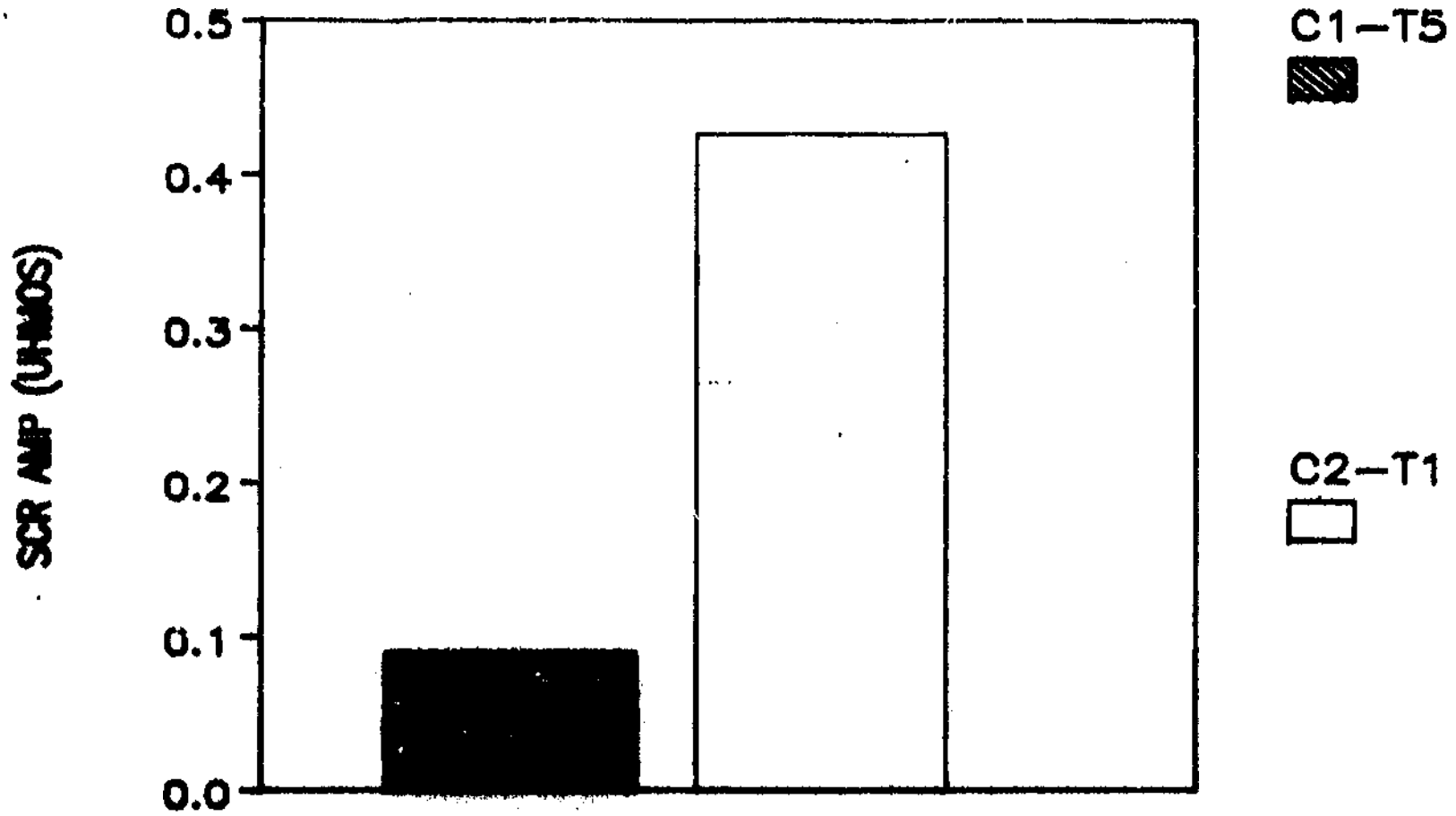

Figure 9. Mean response amplitude (uhmos) to the first presentation of the horizontal bar by condition.

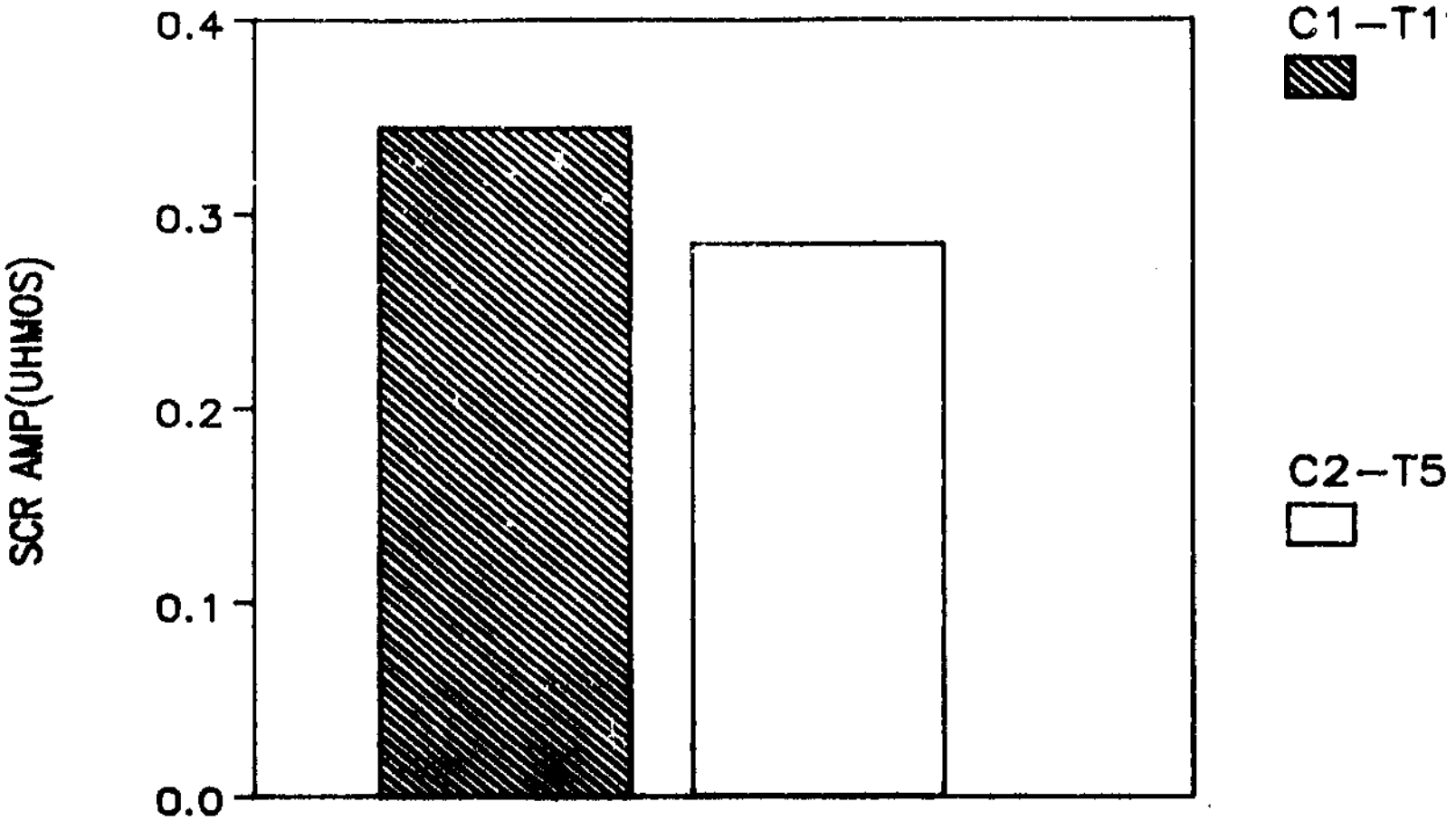

Figure 10. Mean response amplitude (uhmos) to the first presentation of the grid by condition.

Appendix

Instructions

INTRODUCTION:

Our experiment is designed to measure physiological responses to visual stimuli. When the experiment begins, all you are required to do is pay attention to the stimuli that will appear on the computer monitor. For the purpose of the following study, it is important for you to remain attentive throughout the entire experiment.

The stimuli you will see will be appearing about once every 10 - 20 seconds. You don't have to do anything with these stimuli, just attend to them as they appear.

After the experiment is completed, I will notify you over the intercom and then disconnect you from the polygraph.

To begin with, you'll have a short rest period, during which time I will calibrate the instruments. I will inform you via the intercom when we're ready to begin. <NAME>, do you have any questions?

BEGIN SESSION (via intercom):

All right <NAME>, were ready to begin. Relax and pay attention as the various stimuli are presented. The first stimulus will be appearing shortly. Once again, when the experiment is completed, I will inform you over the intercom. We

will now begin...

END SESSION (via intercom):

<NAME>, the experiment is now over. In a moment I'll come in and disconnect you. For now just relax.

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